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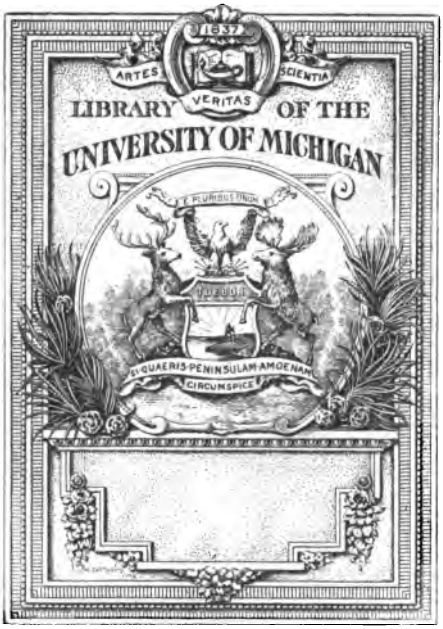
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THE QUARRY INDUSTRY IN SOUTHEASTERN NEW YORK

BY

EDWIN C. ECKEL C.E.

Reprinted from 20th report of the State Geologist 1900

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Monroe shales (Devonian)
Bellvale flags (Devonian) r14
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THE QUARRY INDUSTRY IN SOUTHEASTERN NEW YORK

The following paper is purely preliminary in its nature, a more complete discussion of the subject being reserved for a forthcoming museum bulletin on the *Granites and marbles of New York state*, which is to form one of a series on the building stones of the state. The area discussed in the present paper includes the counties of New York, Queens, Westchester, Putnam, Dutchess, Rockland and Orange. A few quarries in the western half of Fairfield county, Ct., are also described.

The data here presented have been collected during the past four years field work in the area under consideration. Descriptions of several of the quarries have been furnished the writer by Mr H. C. Magnus, who spent some time in 1900 on field work for the state museum in central Westchester county, and by Mr B. F. Hill, who was engaged for several field seasons on work in Putnam county. The writer is also indebted to Mr Joseph Morje for valuable assistance in the preparation of the material for publication. Other acknowledgments are made in the course of the paper.

GEOLOGY OF THE AREA

The area discussed in the present paper, though relatively small, contains representatives of all the geologic systems from the pre-Cambrian to the Trias which occur in New York state. The geologic discussion here presented is merely a summary of those facts of importance in connection with the quarry industry of the area. The areal distribution of the various formations is very complicated and can hardly be explained without reference to a geologic map of fairly large scale. The new edition of the geologic map of New York, on a scale of 5 miles to the inch, will be found serviceable in this connection. Westchester and New York counties, with small parts of Rockland, Orange and Putnam, are well shown on the geologic map of a part of southeastern New York by Dr F. J. H. Merrill, published in 1895.

Rocks

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For a detailed discussion of the geology of this part of the area, reference must be made to Dr Merrill's paper on the "Crystalline rocks of southeastern New York," published in the 50th annual report of the New York state museum. Reports on Orange and Rockland counties, by Dr Ries and Dr Kümmel respectively, have also been issued. The Devonian outlier extending in Orange county from near Cornwall to Greenwood lake, has been discussed in detail by Mr N. H. Darton.

The oldest formation in the area is a series of gneisses of pre-Cambrian age, forming the mass of the Highlands. To the northwest of this range is the great lowland, based on Cambro-Ordovician limestones and shales. A structural basin lying on the northwest flank of the main body of pre-Cambrian rocks, but separated from the Paleozoic lowland in Orange county by a series of small pre-Cambrian outliers, contains Upper Silurian and Devonian formations. East and southeast of the pre-Cambrian mass, on the western side of the Hudson, is a region in which the sedimentary rocks have been highly metamorphosed, the sandstones, limestones and shales of the normal Cambro-Ordovician appearing here as quartzites, highly crystalline limestones, and schists. As a further result of the forces to which they have been subjected the strata, originally laid down in a nearly horizontal position, now form a series of folds, trending generally northeast and southwest, both Paleozoic and pre-Cambrian beds being involved in these folds. South of the pre-Cambrian, to the west of the Hudson river, these altered Paleozoic rocks are almost entirely overlain by the Newark rocks, which cover most of Rockland county. In addition to the formations noted above, which are parts of a normal succession, igneous rocks occur as intrusives of later date.

SUCCESSION OF THE FORMATIONS

Pre-Cambrian rocks

The pre-Cambrian rocks of southeastern New York consist of a series of gneissoid granites and gneisses, locally schistose. In Westchester county the more massive (and in general more

Plate 43

To face p. r144

F. J. H. Merrill, photo.

Pre-Cambrian gneiss, Lake Mahopac N. Y.
Photomicrograph in polarized light, enlargement 22 diameters.

basic) lower gneisses are overlain by a highly foliated gneiss, described by Dr F. J. H. Merrill as the Fordham gneiss. This is a well banded bluish to gray gneiss, consisting of alternating layers of quartz, orthoclase (or microcline) and mica (usually biotite).

Lithologic differences, fairly constant over large areas, have led to a tentative fourfold division of the pre-Fordham gneisses; but the grouping depends on composition rather than on superposition, and has therefore no chronologic significance. The names for these subdivisions have been used, in manuscript only, by the present writer: and the subdivisions will not be discussed in the present connection.

Various authors have included in the pre-Cambrian both the large area of white limestone of Sussex county, N. J. and Orange county, N. Y. and smaller isolated areas which occur in the Highlands of Putnam and Orange counties. Recent field work by the writer in these smaller areas seems to disprove this conclusion, at least so far as some areas are concerned; and it is probable that the entire question may still be considered open. In the present paper, however, these Highland limestones have been discussed separately from the undoubtedly Paleozoic limestones and marbles. Lithologically, these white limestones differ but slightly if at all from the more highly crystalline portions of the Stockbridge, and like the Stockbridge and Barnegat are usually highly magnesian.

Poughquag quartzite

In Dutchess, Orange, Putnam and Westchester counties a relatively thin quartzite usually underlies the Cambro-Silurian limestones. In Stissing mountain and at other points this quartzite has been found to contain Lower Cambrian (Georgian) fossils. It is essentially continuous, stratigraphically, throughout the counties above named, few contacts of the Stockbridge limestone with the pre-Cambrian gneisses failing to show this intervening quartzite. In its lithologic character it is very uniform. Dr Merrill described it in 1896 as the Lowerre quartzite, while the formation names Vermont and Cheshire have been

given it by the New England geologists. The name recently adopted for it is Poughquag quartzite (Dana 1872) in recognition of the fact that its thickness, lithologic character and stratigraphic position are well shown at Poughquag, Dutchess co. N. Y. A typical exposure of the Poughquag quartzite occurs on the south side of Peekskill creek near its junction with the Hudson river. This is well shown on pl. 54, the slaty cleavage of the quartzite being particularly noticeable.

Stockbridge and Barnegat limestones

The Barnegat or blue limestone of Orange and southwestern Dutchess county and the crystalline Stockbridge limestone of the other southeastern counties and western New England, are more or less highly metamorphosed equivalents of the Cambro-Silurian limestones of northern Dutchess county. As a whole, the Barnegat and Stockbridge formations are predominantly magnesian. They rarely carry sufficient magnesia to qualify as true dolomites, however; and contain occasional beds of almost pure lime carbonate.

The crystalline Cambro-Silurian limestone of Westchester county was described as the Inwood limestone by Dr F. J. H. Merrill in the paper previously cited. These Westchester county limestones are essentially continuous, stratigraphically, with the Stockbridge limestone of the Taconic region; and in order to prevent two names being used for the same formation, the formation name Stockbridge has been accepted as that of earlier date.

Mather in 1842 described the semicrystalline blue limestone of Orange county as the Barnegat limestone. Though there seems to be little doubt of the essential equivalence of the Barnegat and Stockbridge, it seems best to retain both names as the Stockbridge probably includes Trenton beds, which in the less metamorphosed area of Orange county and New Jersey can be differentiated from the Barnegat. South of the New York line the names Kittatinny and Wallkill have been applied to the Barnegat limestone, but these can hardly be regarded as tenable in view of the many other names of earlier date.

Hudson shales and schists

The Hudson shales of the Hudson valley are represented in the metamorphic area of southeastern New York and western New England by a thick series of slates and mica schists. The transition from shale through slate to schist can be well observed in traveling across Dutchess county from west to east in the latitude of Poughkeepsie; and the term Hudson schist has recently been adopted in place of the terms Manhattan schist (of New York geologists) and Berkshire schist (employed by the United States geological survey workers in New England). The Hudson formation is of little economic importance, though much schist has been employed in foundation and retaining wall work on and near Manhattan island, and thin layers of sandstone occurring in the shales have been worked in Dutchess county.

Green Pond conglomerate

The name Green Pond conglomerate was given by Darton in 1894 to a formation occurring on the borders of the Devonian outlier noted on p. r144. The principal exposures of this formation, in the area here discussed, are west of Cornwall station and in Pine hill near Highland Mills, both in Orange county. The rock is a conglomerate consisting of white to pinkish quartz pebbles, embedded in a reddish silicious matrix. Darton states that in this vicinity the formation is not over 60 feet thick. In stratigraphic position the Green Pond conglomerate, Pine Hill quartzite and Longwood red shales correspond approximately to the Shawangunk grit of Ulster county, and to the Medina (including Oneida) rocks of western New York.

Pine Hill quartzite

The name Pine Hill quartzite is here proposed for a series of quartzite beds overlying the Green Pond conglomerate and underlying the Longwood shales. The formation is well shown in Pine hill, east of Highland Mills, Orange co. Transition beds between the quartzite and conglomerate and between the quartzite and shales occur; but in general the lithologic dis-

tinctions between the formations are evident. The Pine Hill formation is 250 feet thick in New Jersey, according to Darton, thinning northeastward to 5 or 6 feet at Cornwall.

Longwood red shales

Darton applied this name in 1894 to the series of shales overlying the quartzite last described. The formation, in Pine hill, shows a thickness of 75-100 feet, and is of considerable (local) economic importance. The shales are in general red, occasional bands of olive shales locally occurring.

Cornwall limestones

A series of thin beds of limestone overlies the Longwood shales at several points in Orange county. These beds carry fossils which serve to correlate them paleontologically with the Lower Helderberg and Waterlime rocks farther west. The term "Cornwall limestones" is not here proposed as a formation name, but is used merely as a convenient designation for the series till further field work shall have decided the extent to which subdivision can be carried. No quarries are at present worked in these limestones.

Newfoundland quartzite

This formation, usually a light colored quartzite but locally conglomeratic, carries at some localities fossils which would correlate it paleontologically with the basal Devonian Oriskany quartzite. The formation name here proposed is in allusion to the exposure of the quartzite at Newfoundland N. J., where its lithologic and paleontologic characters are well shown and were described by Britton and Merrill in 1886.[1] It is exposed at several other points along the margin of the Devonian outlier in both New York and New Jersey. No quarries in this formation are worked in the area under discussion.

Monroe shales

This name was applied by Darton in 1894 to the dark colored shales underlying the Schunemunk conglomerate and in places overlying the Newfoundland quartzite. Fossils correlate them

[1] N. J. state geol. Rep't. 1886.

approximately with the Hamilton of the counties farther west. These shales are quarried at several points for local use as road metal, but are of no great economic importance.

Bellvale flags

The name Bellvale flags was given by Darton, in 1894, to the hard, thin bedded gray sandstones which appear, overlying the Monroe shales, in Schunemunk, Bellvale and Bearfort mountains. Plant remains occur[1] in these flags, and fix their age as middle Devonian.

Schunemunk conglomerate

Overlying the Bellvale flags in the mountains above named is a conglomerate of quartz and quartzite pebbles in a reddish silicious matrix. In 1894 Darton named this the Schunemunk conglomerate. He states that lithologically it differs from the Green Pond conglomerate in containing quartzite pebbles, which are absent in the latter.

Newark beds

The Newark beds of central and western New Jersey have been divided by Kümmel into three superposed "formations." These "formations" change in lithologic character as the New York line is approached. Two of them, according to Kümmel, appear in Rockland county N. Y. They have not been mapped separately however, and will not be separately treated in this paper. Calcareous conglomerates, which appear near the northern edge of the Newark area, have afforded some lime.

IGNEOUS ROCKS

Cutting certain of the formations above noted, granites and other igneous rocks are frequently found in dikes or masses. These igneous rocks vary greatly in composition and texture as well as in economic importance. Of the many varieties present, four show well marked and distinct types and occupy definite areas of considerable size. For this reason they have been assigned names as follows (being named after the localities at which they are best developed): Yonkers gneiss, Harrison

[1] Martin, D. S.
Prosser, C. S. N. Y. acad. sci. Trans. 11: 132-51.

diorite, Cortlandt series (norite, diorite, etc.), Newark diabase. The remaining rocks of igneous origin, occurring in areas too small to be separately named may, for our present purpose, be grouped as granites.

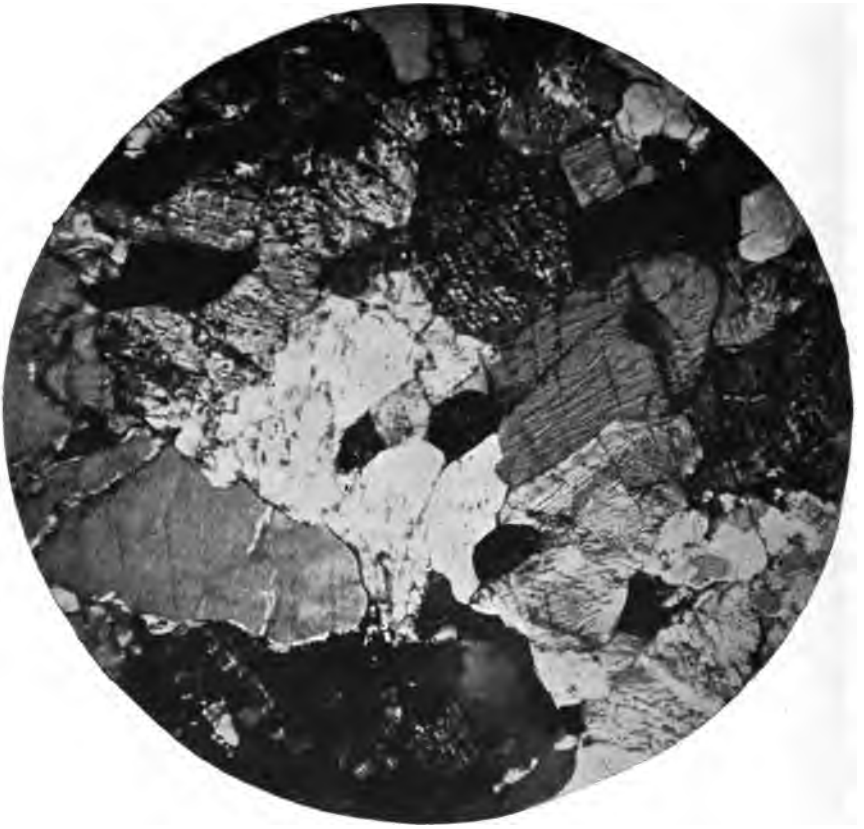
QUARRY INDUSTRY OF THE AREA

PREVIOUS PUBLICATIONS

Prof. J. S. Newberry, in his report on *Building and ornamental stones*, Philadelphia exposition, 1876, discussed at some length the Tuckahoe and Pleasantville quarries, and their product. The *10th census report on the stone quarry industry* contains short notes on the marble quarries and a brief mention of the Lefurgy quarry (in Fordham gneiss) at Hastings. In addition, however, this report contains an exceedingly valuable and comprehensive paper by Dr A. A. Julien on "Stone construction in New York city and the vicinity," with detailed information regarding the durability, etc. of all stones, domestic or foreign, used here. In his two reports on the *Building stone of New York state*, published as bulletins 3 and 10 of the New York state museum, Prof. J. C. Smock describes the quarries of the entire state in great detail, giving physical and chemical data in bulletin 10. These reports, abstracts of which have appeared in bulletin 15 of the New York state museum, contain the best descriptions yet published of the quarries and quarry industry in Westchester county, being defective only in regard to the Yonkers gneiss, quarrying in which was not actually begun till several years after the publication of the bulletins. All these reports, however, suffer from one common and unavoidable defect. At the time at which they were written the geologic structure of the area had not been made out with any degree of certainty, and the reports consequently err in grouping together quarries which are worked in entirely different geologic formations. For this reason, it has been in some instances extremely difficult to identify the material on which the tests quoted were actually made.

A report on the geology of Orange county by Dr Heinrich Ries, published in the 15th report of the New York state geologist, contains notes on the quarry industry in Orange county.

Plate 44 To face p. r151



F. J. H. Merrill, photo.

Pre-Cambrian gneiss, Breakneck mountain, N. Y.
Photomicrograph in polarized light, enlargement 22 diameters

GRANITE: INCLUDING GNEISS, DIORITE, TRAP, ETC.

Lower pre-Cambrian gneisses

Storm King station, Putnam co. Quarries (1) in Breakneck mountain at this station formerly furnished a large amount of stone for building work and also of crushed stone for railroad ballast. Bailey's quarry, (1) a few hundred yards south of the station, is still worked at intervals, but the output is small. The rock in which the quarries are located is a medium grained gneissoid granite containing a large amount of hornblende. In color it varies from dark greenish to redish. A thin section of this rock is shown on pl. 43.

Carmel, Putnam co. Two quarries in pre-Cambrian gneiss are located one (3) on the west side of the West Branch reservoir, the other (2) on the east side of the reservoir. Both furnished material for the dams and reservoir walls.

Peekskill, Westchester co. A small quarry located near the east bank of the Hudson river, about 3 miles northwest of Peekskill, has not been worked for some years. The rock is a rather coarse grained, light colored, gneissoid granite.

Glenham, Dutchess co. A reddish gneiss has been quarried to a small extent near Glenham, Dutchess co. (4). The product was used for macadam on local roads. The quarry is located north of and near Fishkill creek, in the small outlier of pre-Cambrian gneiss which extends from near Glenham northeastward to Vly mountain. The material is unsuitable for structural work.

Theill, Rockland co. Pre-Cambrian gneiss has been quarried just north of the station of the New Jersey and New York railroad at Theill, Rockland co. (5). The material outcropping at the quarry is closely jointed, and breaks readily along the joint planes. It has been largely used for macadam on neighboring roads, but will probably be superseded by trap from the new quarry south of Theill.

Suffern, Rockland co. Several quarries (6) are worked north and northwest of Suffern by Rice Bros. and the Hillburn granite co. The rock here quarried is a pre-Cambrian gneiss, not very

highly foliated, and consisting chiefly of quartz, plagioclase (with subordinate orthoclase) and hornblende. The feldspars are usually white, varying to reddish; and the gneiss is accordingly gray to light reddish in color. Part of the stone is used, rough dressed, for foundation and wall work; but a considerable quantity is cut by Copeland & Son at Suffern, being used chiefly for monuments.

Arden, Orange co. Several quarries (7) between Arden and Tuxedo Park have been worked quite extensively for road metal. The material is a hornblendic pre-Cambrian gneiss, not suitable for dressed stone, but as road metal producers the quarries are of some local importance.

Monroe, Orange co. A pinkish gneiss occurs in an area of considerable size about 2½ miles southeast of Monroe, Orange co. It has never been worked, but judging from the outcrop should furnish stone of good quality. So far as color is concerned, it is probably the handsomest granite in southeastern New York.

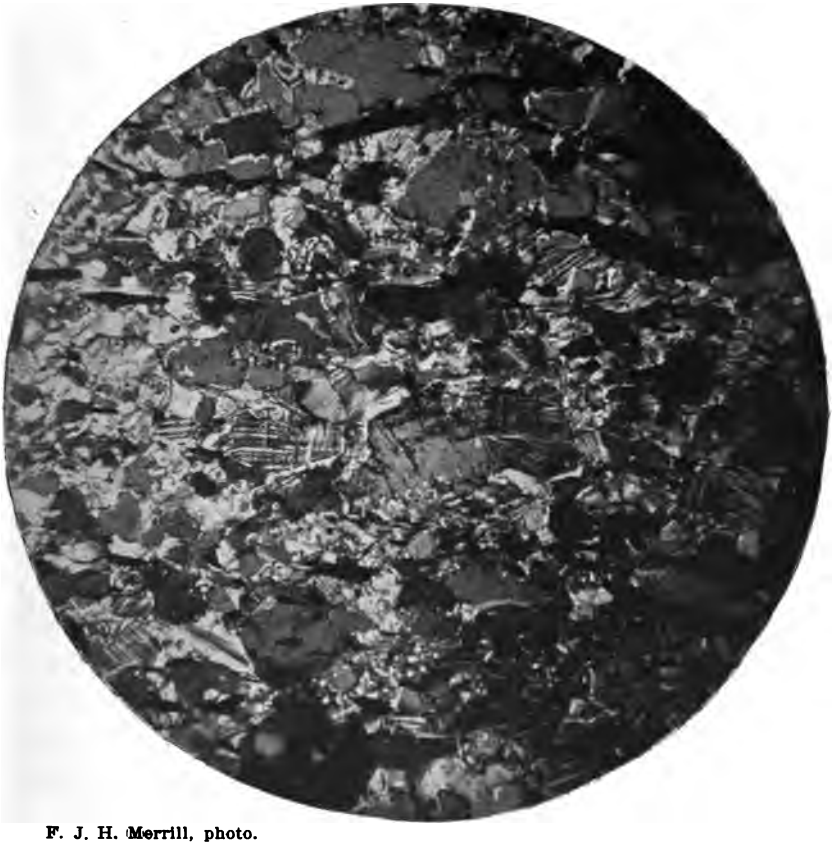
Fordham gneiss

The Fordham gneiss is typically a light grayish or bluish, well banded gneiss, consisting of biotite, orthoclase and quartz. Its upper[1] beds near the contact with the Poughquag quartzite are always highly quartzose; and this upper part of the formation is possibly of sedimentary origin. The Fordham gneiss has been largely used for foundation stone and other uncut work. The Hastings quarry formerly sold a fair proportion of its product as cut stone, but of late years little of this grade has been marketed. It has also been used to some extent for macadam, but is hardly well fitted for this purpose as it generally breaks into flat pieces when put through a crusher.

[1] "Upper" is used here in a geologic sense. Folding of the rock series may cause the newer (and geologically "upper") beds to apparently underlie the older (and geologically "lower") beds. This is well shown at the old marble quarry near Hastings, Westchester county. The series here has been sharply folded so that the limestones are shown dipping to the east, apparently under the quartzite and gneiss which are exposed near the top of the eastern wall of the quarry; but the limestone is really newer than the gneiss and quartzite.

Plate 45

To face p. r152



F. J. H. Merrill, photo.

Fordham gneiss, Lefurgy's quarry, Hastings N. Y.
Photomicrograph in polarized light, enlargement 22 diameters

Mail

It has, however, been used to a considerable extent for railroad ballast.

Hastings, Westchester co. *Lefurgy's quarry* (9). Owned by ——— Lefurgy; operated under lease by William Nichols jr. Known at one time as Munson's quarry. Situated about half a mile west of Mt Hope station, on the western side of the gneiss ridge. It is opened for a distance of about 350 feet along the strike, and is about 100 feet wide. The west wall is 30 feet high at its northern end, running down to near ground level at its southern. The east wall is about 100 feet high at its northern, and 20 feet at its southern end. The floor of the quarry is at present only a few feet below ground level, though it was at one time worked 10 feet or more below, this low cut having been subsequently refilled. The entrance to the quarry is at the south end where a road leads out to the main road to Hastings.

The west wall shows biotite schist and much crumpled gneiss, and has been practically untouched since the opening of the quarry, all the development having taken place toward the east and north. The northern face shows a good quality of light gray or bluish gneiss, typical Fordham, a thin section of which is shown on pl. 45. In it are two seams 2 to 3 feet wide, of hornblende-biotite gneiss, regularly laminated, and of rather good grade. They would certainly furnish attractive cut stone. The east face is now beginning to cut a crumpled area, containing frequent interbeddings of a rock composed of pink feldspar, a silvery mica, and some garnets. For this reason the quarry has probably reached its extreme eastern development, most of the stone now being taken from the north face. The pink intrusive mentioned seems to be usually accompanied by a walling, 2 inches or so thick, of biotite schist. Near it quartz lenses and stringers are common, and are also usually walled by biotite schist. Strike and dip average n. 24° e., 71° e.

Two derricks (horse) are in place. There is usually little trouble from water, though in certain seams enough has been encountered to embarrass the blasting (black powder).

For the past three years no cut stone has been furnished by this quarry. In 1898 the total output was valued at about $1300, and was mostly used for foundations and backing. For this material $1.50 a cubic yard is obtained. Expense of lifting, handling and transportation prevents competition, even locally with the New England and Hudson river stones. The quarry will probably soon be abandoned because of the poorness of east and west walls, and because adjoining lots have been sold for building. Mr Nichols then expects to commence quarrying on his own land, a little farther north on the same ridge.

Uniontown, Westchester co. A quarry (10) here was worked for a time in order to get rough stone backing for one of the Warburton avenue bridges. The opening is in a light colored (gray) gneiss, with several pink seams. The mass of the rock, however, shows little or no injection. Strike and dip n. 25° e., 56° e. The product shows too much contortion in the layers to permit the quarry, if ever reopened, to become a serious competitor of Lefurgy's.

Bryn Mawr, Westchester co. Along Palmer avenue, west of Bryn Mawr, near Fort Field reservoir, two small openings (12) have been made in Fordham gneiss. The easternmost is in a rather poor grade Fordham, minutely crumpled and breaking into tabular pieces. The westerly opening is in better rock, and supplied part of the stone for the reservoir walls and gatehouse. Both openings were worked later to supply macadam for Palmer avenue. Pl. 46 shows a face of the Fordham gneiss exposed in excavating for Fort Field reservoir, and pl. 47 the gatehouse, built from good specimens of this gneiss.

Lowerre, Westchester co. In Lowerre small quarries (11) were opened in 1898. The rock was a rather poor Fordham gneiss, with granite injections along certain bedding planes and a pegmatitic dike crossing the bedding. The total product to May 1, 1899, was about 2000 loads. Rough stone brought 75c to 85c a load, while larger stone, roughly trimmed, was worth $1.50. The material was used for foundations, etc. Four men were employed. This stone was badly jointed, and could be handled

Plate 46

To face p. r154

Fordham gneiss, showing foliation. Fort Field reservoir, Yonkers N. Y.

NOU

Plate 47

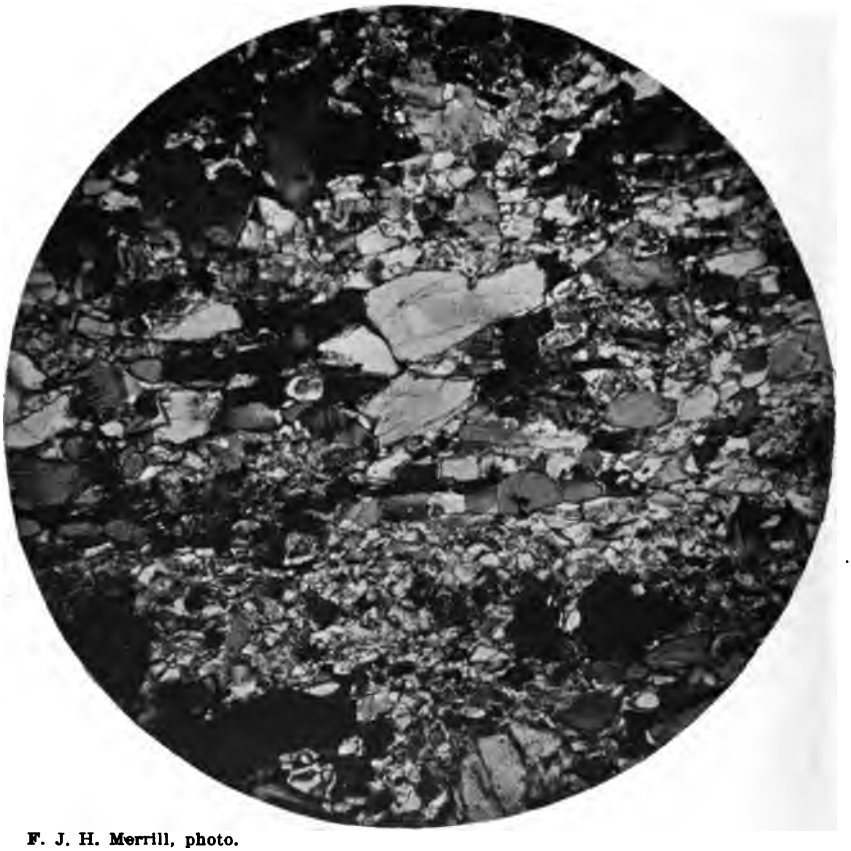
To face p. r154

Gatehouse, Fort Field reservoir, Yonkers N. Y.
Built of Fordham gneiss

Mail

Plate 48

To face p. r155



F. J. H. Merrill, photo.

Yonkers gneiss, Hastings N. Y.
Photomicrograph in polarized light, enlargement 22 diameters

in face of competition of the Yonkers gneiss quarries only because of shorter haul and the fact that removing the stone was raising the value of the lots.

Fordham, Westchester co. Fordham gneiss was formerly quarried (8) west of the Harlem railroad, south of Fordham, in the upper beds, much of the product being used for railroad ballast. It has also been quarried for road metal, for which purpose it is not well suited, at various points in Westchester county, but none of these small quarries are now working and none were ever of much importance.

Yonkers gneiss

The Yonkers gneiss is a well foliated gneissoid granite, very variable in color, grain, and economic value, but quite uniform petrographically. It is composed essentially of quartz, biotite, microcline, and sheared orthoclase. Normal orthoclase is not abundant, while plagioclase is very rare. Hornblende is the most common accessory, being very abundant in certain seams, and rarely entirely absent from a slide. Titanite is very frequent. A thin section is shown on pl. 48.

The color of the Yonkers varies from a light blue to a rather deep red. This variation is partly due to the fact that the blue grades in most cases contain more quartz and less feldspar. A much more potent cause, however, is that the feldspars themselves are either red or bluish. This difference in color is not due to a difference in the feldspar species, as the microcline and sheared orthoclase appear in both the red and blue Yonkers, and in about the same relative proportions.

The difference in color is of importance economically. The red forms decay readily while the blue, though often becoming stained yellow by iron, do not appear to disintegrate. The writer has not been able to follow up this investigation as far as he could have wished, and the discussion in this paper should be regarded as merely preliminary to a more detailed presentation of the subject.

The principal area of Yonkers gneiss is located in the southern part of Westchester county. It extends from near Van Cort-

landt Park to Scarsdale, and occupies most of the ridge between the Bronx valley and the valleys of Tibbet and Troublesome brooks. Smaller areas occur northeast of White Plains, east of Hartsdale and at several other points mentioned below.

Most of the quarries in the main belt of Yonkers gneiss were opened around 1892. At that time an unusual amount of bridge and retaining wall work was being done by the Putnam, Harlem and New Haven railroads. Dimension stone and cut stone of smaller size was in great demand, and most of it came from the quarries in the Yonkers belt. This period of prosperity continued throughout 1892, 1893, 1894 and 1895. Since then the actual railroad demand has fallen off, and in addition, Palatine Bridge limestone is being used in place of the gneiss. During the "railroad" period it is probable that at least 100, possibly more, men were employed in the line of quarries running from Scarsdale to Dunwoodie. In 1899 about 15 to 20 quarrymen, with possibly 10 teamsters and teams, were employed. The year 1899 was, however, abnormally dull. The data quoted later may be taken as an average for the years 1896, 1897 and 1898.

Mr S. L. Cooper, commissioner of public works, city of Yonkers, wrote, in reply to an inquiry concerning the use of Yonkers gneiss by his department:

The quarries you mention (Hackett, Cahill, O'Rourke) are the only ones now furnishing stone to the public works of this city. It is impossible to state with precision the amounts, but they have been about 2000 to 2500 cubic yards a year for the past three years. The contract prices depend largely on the length of haul. For macadam, telford stone and ordinary foundation or quarry-broken building stone, the price will vary from $1 to $1.50. For cut stone the price is about $40 a cubic yard for fine cut (8 cut) work. This is for cut-face and quarter-inch joints. Our local stone has been used for macadam only on the country roads, and the prices named above do not, of course, include the breaking of the stone to macadam size.

Since the decline of the railroad trade, the quarries depend largely on rough foundation stone, etc. to pay current expenses and fixed charges. This trade is, of course, very evenly distributed among the various quarries, as the difference in quality

or price of this class of stone is not sufficient to give a decided advantage to any one quarry. Seely's quarry, at Scarsdale, is handicapped by greater distance from market, as little building is going on near it. Lowerre and Park Hill use a considerable quantity of this class of stone. A certain quantity of cut stone, about 2 feet by 2 feet by 18 inches in size, is used for private houses and for walls. This item is, however, of little importance.

The chief profit of the quarries comes from stone supplied to public buildings, schools, etc., for which a high grade of cut stone is required. Occasionally large semipublic buildings—hospitals, libraries, etc.—are erected, and to supply stone for these is almost as profitable.

As good trap and limestone can be obtained cheaply from the Palisades and Tomkins Cove, little stone is furnished by the local quarries for macadamizing. Occasionally, however, the Yonkers gneiss is used for this purpose on second class roads. The stone is then handbroken at the quarry, unless the buyer owns a crusher. Almost all of the so-called macadam roads are in reality telford roads, having a subpavement of large (5 to 8 inches) stone. The local quarries furnish most of this telford, using for it their worst grade, the coarse red Yonkers gneiss.

Scarsdale, Westchester co. *Seely's quarry* (19). Owned and operated by H. S. Seely. Several openings on the north side of Platt avenue, about half a mile west of Scarsdale station. The opening now worked is on the extreme west of the group, and has been worked for 100 feet along the strike. It is 30 feet wide and 10 to 20 feet deep, being entirely below the general ground level. A larger opening, on the extreme east of the group, shows an 8 foot bedded dike of a coarse-grained hornblende-feldspar rock. The average quality however, is very high; a large percentage of the material being the blue Yonkers. No machinery is on the ground, save one derrick—horse power. The product has, for five years or more, been only foundation stone. It will not exceed 150 cubic yards annually for which

$1 to $1.50 a yard (delivered) is obtained. Should a contractor wish to do his own quarrying a royalty of 25c a yard is charged. Selected and roughly trimmed stone brings $2 a yard. This quarry got a fair share of the railroad business but has been practically idle since that time.

Dunwoodie, Westchester co. *Hackett's quarries* (14). Worked and owned by Hackett Bros. of Dunwoodie. Located at the intersection of Central and Midland avenues, a mile or so northeast of Dunwoodie station. A small opening, with one derrick, is in the southwest angle formed by the intersection of the two avenues mentioned; the larger and older quarries are in the northwest angle. The quarry now worked has been opened for about 300 feet along the strike and about 80 feet across the strike. The foliation planes dip and strike n. 30° e., 85° w. One set of almost horizontal joints divides the rock into "beds" about 4 feet thick, while the set of joints parallel to the foliation are about 2 to 4 feet apart; and a third less important and regular set of joints strikes and dips n. 64° w., 75° w. Most of the quarry is above the ground level of its front. Stone from this quarry has been used in St Joseph's seminary, Dunwoodie, Seton hospital (Spuyten Duyvil), St John's hospital (Yonkers) and St Joseph's hospital (Yonkers), and in much railroad work, as well as in several Yonkers schoolhouses. In 1898 Hackett supplied some polished columns from this quarry for the county jail at White Plains. The polishing was done in New York city, and the columns are good samples of the best grade of the Yonkers gneiss. Four derricks (one run by steam, three by horse power) and one boiler are on the ground.

Mr Hackett estimates the annual product at 500 cubic yards macadam stone, 1000 cubic yards foundation stone and 100 cubic yards dressed stone. The main opening is shown on pl. 49.

Cahill's quarries (15). Owned and operated by Dennis Cahill of Yonkers. Situated on Midland avenue, several hundred yards east of Central avenue. The smallest and newest opening, at which a boiler is located, on the south side of Midland avenue, will probably be the principal quarry of the future. The

To face p. r158

E. C. Eckel, photo.

Hackett's quarry, Dunwoodie N. Y.
(Yonkers gneiss)

E. C. Eckel, photo.

Flannery's quarry, Dunwoodie N. Y.
(Yonkers gneiss)

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Plate 50 To face p. r159

E. C. Eckel, photo.

O'Rourke's quarry, Dunwoodie N. Y.
(Yonkers gneiss)

larger openings are north of Midland avenue. The one now worked has been opened for a distance of 250 feet along the strike, and has been worked backward (toward the west) about 200 feet. The space worked out is filled up with waste rock. The foliation planes strike n. 22° e. and dip 70° to 90° w. One almost horizontal set of joints, dipping slightly to the east, divides the rock into 4 to 12 foot "beds." A less regular set strikes n. 65° w. and dips 67° w. One derrick is in use—horse power. Four quarrymen and a foreman are employed. The quarry was opened in 1892, and got much of the railroad work. Two schools were lately supplied, the cut stone being valued at about $5.50 a yard at the quarry. Smaller cut stone is sold, delivered, at about 30c a cubic foot. The annual product amounts to about 2000 cubic yards rough stone, valued at about 50c a cubic yard at the quarry; and about 100 to 200 cubic yards of dressed stone.

As in all the Yonkers gneiss quarries, black powder is used when necessary, but much of the stone can be gotten out by use of the plug and feathers. These are always used for splitting the stone to size after it has been broken out in blocks. The stone stands bush hammering well, and this is about the highest finish ever given it.

O'Rourke's quarry (17). Worked on lease by E. O'Rourke of Dunwoodie on land belonging to the Stewart estate. Opened for 65 feet along strike, 25 feet on dip, 15 to 20 feet deep. The opening is shown on pl. 50. Foliation places strike n. 32° e. and dip 66° e. The stripping was about 6 feet. Annual product about 1000 cubic yards foundation stone, at $1.75 a cubic yard, delivered, and 600 cubic yards cut stone, valued at $4000. This quarry shows a larger percentage of high grade stone than do any of the others. It was opened too late to get much of the railroad work, except the piers of the trestle at Lowerre, but gets a fair share of public and private work.

Flannery's quarry (13). This quarry was worked irregularly by the owner of the land, ———— Flannery. He is a builder and the product was used exclusively on houses which he built.

The quarry has been idle during recent years. The opening is about 100 feet long by 100 wide and 20 deep. The best stone, which is a very fair grade of Yonkers, is at the west side, the eastern side and center showing very thin-bedded stone. The quarry is shown on pl. 49.

Valentine quarries (16). Several small openings exist nearer Dunwoodie. It is stated that these were worked eight or 10 years ago. This information, taken together with their location, makes it probable that they are the quarries described by Smock as the Valentine quarries and mentioned by Mather in 1843. At any rate, they are of historic interest as being the first quarries operated in the Yonkers gneiss belt.

Millwood, Westchester co. Quarries (24), formerly much worked for railroad ballast, occur at Merritt's Corners (Millwood), on the New York and Putnam railroad. The rock is a reddish gneiss, resembling some phases of the Yonkers gneiss. The foliation strikes n. 32° e. and is almost vertical in dip.

White Plains, Westchester co. Collin's quarry (22) is located about 1 mile northeast of Silver lake, the quarry being shown on pl. 51. The material shown in both the openings is a fairly well foliated reddish gneiss of the Yonkers type. It is heavy bedded, and the horizontal joints are far enough apart to permit the extraction of good sized blocks of stone. At present the local demand is insufficient to warrant steady working.

Hartsdale, Westchester co. McCabe's quarry (20) is situated about 1 mile east of Hartsdale station, in a narrow belt of Yonkers gneiss. The rock is of fair quality. Little has been used for structural work as rough stone; but a considerable quantity has been supplied for macadamizing roads in the vicinity. The material exposed is very light bluish in color and highly foliated.

Hastings, Westchester co. Rowley's quarry (23), situated a little east of the old aqueduct and a mile or less south of Hastings, is in a rock which may be considered Yonkers gneiss. Rowley's quarry was worked for a time to supply stone for a bridge on Warburton avenue. The stone obtained was too folded and dis-

Plate 51

To face p. r160

E. C. Eckel, photo.

Collins's quarry, northeast of White Plains N. Y.
(Yonkers gneiss)

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torted to be used for anything save backing and probably not over 500 cubic yards were used even for that. It is cut by three sets of joints—two approximately vertical, and one horizontal. They strike and dip respectively n. 37° e., 85° w.; n. 73° w., 80° e.; and n. 23° e., 20° w. Fragments of vein quartz, with faceted surfaces, were found on the dump, and several specimens of chalcopyrite were seen. Pegmatitic material also occurs. Much of the rock is highly micaceous and thin bedded, while the more solid portions are too much distorted to be used for face stones. The quarry will probably never be reopened.

Tarrytown, Westchester co. The old Beekman quarry (23a), on land belonging to the Kingsland estate, is located about 1 mile north of Tarrytown, near the Hudson river. It was formerly largely worked both for structural stone and, later, for railroad ballast. The material is a bluish to reddish gneiss similar in mineral composition to the Yonkers gneiss. Examples of it can be seen in several churches and other large buildings in Tarrytown. Gillmore reports a gneiss from Tarrytown, probably from this quarry, as showing in 2 inch cubes a compressive strength of 18,250 pounds a square inch, and as having a specific gravity of 2.655.

Ravenswood, Queens co. The eruptive area in Ravenswood L. I. (25), is composed of rock allied to the Yonkers gneiss but containing plagioclase in addition to the sheared orthoclase of the normal Yonkers. The occurrence of perthite in pegmatitic bands is noteworthy. It has been used to some extent in foundations, walls, and even buildings in the vicinity, according to my observations. Most of the area, however, falls within the limits of a public park.

Granites and allied rocks in small areas

At many points in the area under consideration the members of the normal succession are cut by dikes and bosses of granites and granite-diorites. Coarse grained (pegmatitic) intrusives are of very frequent occurrence, particularly on and near Manhattan island, where such dikes are frequently shown cutting the Hudson schists. These materials are, of course, of no eco-

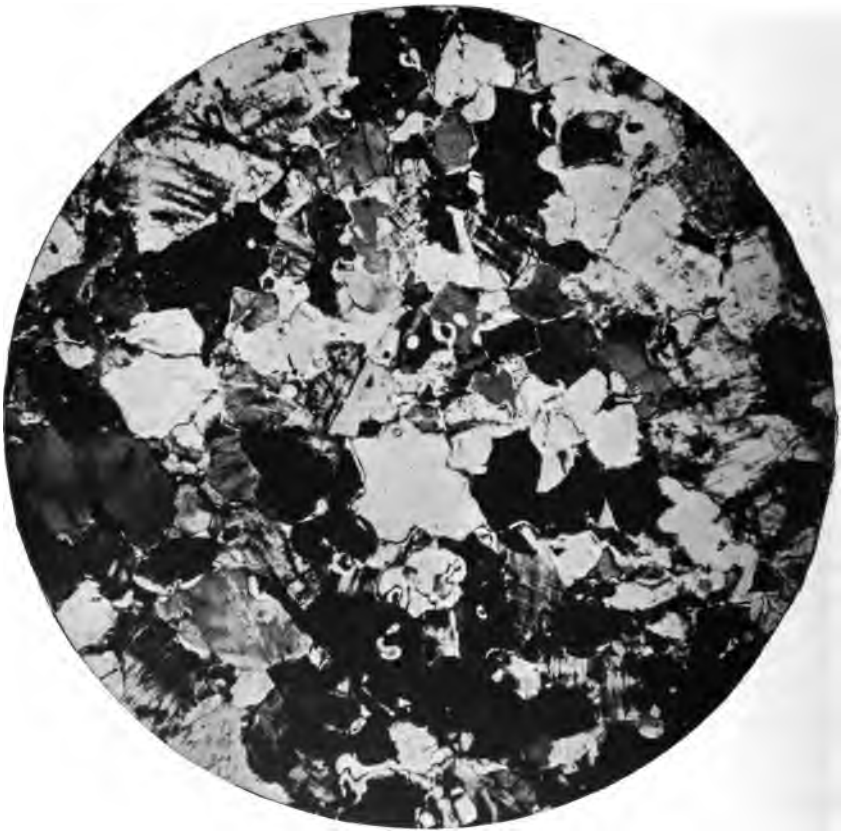
nomic value. Finer grained granites occur, however, and are worked at several points within the area. Few of these quarries are so located with regard to water transportation routes as to be of more than local importance. The quarry most favored in this respect is King's, located near Garrison, Putnam co. Two quarries near Lake Mohegan, Westchester co., are of interest because of the importance of the works in which their product is used, as they supply respectively the new Croton dam at Quaker Bridge and the Cathedral of St John the Divine in New York city.

New Rochelle, Westchester co. *Ash's quarries.* Edwin Ash of New Rochelle works a group of small quarries (28) in the granite area northeast of that village. The poorer grade of stone is sold as foundation stone at 75c to $1 a load. The better grades he uses himself on monument work. The granite of this area is, in general, of very poor quality. It is often much foliated and contorted. Veins and pockets of pegmatitic material are scattered through it profusely. A slide showed feldspar, quartz in subordinate amount, biotite present but not in great quantity and a few large flakes of muscovite. The feldspars present were plagioclase, microline and orthoclase. Few minor accessories were present. The components noted above place this rock between the granites and the quartz diorites. The feldspars were much clouded. The stone is hardly suitable for building purposes for though the outcrops do not seem to be much disintegrated, yet the stone, in hand specimens or the mass, does not have a firm and durable appearance.

Mount Vernon, Westchester co. Fairchild's quarry (27) is owned by Fairchild Bros. of Mount Vernon. The quarry is an opening about 200 feet long (east to west), 60 feet wide and 35 high, situated on the southern face of a ridge near East Mount Vernon. The rock is a bluish, very tough and compact granite. Slides show microline to be the predominant feldspar, with some orthoclase and a little plagioclase. Muscovite is in long coarse flakes and biotite in smaller flakes are present in

Plate 52

To face p. r163



F. J. H. Merrill, photo.

Granite, King's quarry, near Garrisons N. Y.
Photomicrograph in polarized light, enlargement 22 diameters

about equal quantity. The grain is small and the feldspars fairly fresh. The rock is so thinly and irregularly jointed that it is not much used for building stone. Even with great care, not over 5% to 10% of the total product could be gotten out in large enough blocks to use for structural purposes. At present it is crushed at the quarry and sold for local use as macadam. A 40 horse power boiler runs the drills (McKiernan) and a Brennan crusher (18 horse power engine). The crusher can turn out 50 to 65 yards of crushed stone a day. The stone was first used in building macadam roads in 1891. It was found that the granite does not grind up into impalpable dust as does trap or limestone but in dry weather loosens up into a heavy dust about the character of coarse sugar, and on being watered packs down again into a hard road. The roads in their wearing quality have exceeded expectations, particularly where the road-bed was on wet soil. The white color of the road is somewhat objectionable during the summer on account of the glare.

Lake Mohegan, Westchester co. Intrusive granites are being extensively quarried at two points about 1 mile south of Lake Mohegan. All the product of both quarries is used as cut stone, that from the northern quarry (30) in the new cathedral (St John's) in New York city, while that from the southern quarry (29) is used on the new Croton dam at Quaker Bridge. The stone is a yellowish to pinkish, medium grained granite, discolored in places apparently by decay of its contained biotite.

Garrisons, Putnam co. King's quarry (31) is located about 2½ miles south of Garrisons, Putnam co., and ¼ mile east of the Hudson river. It is owned by the King granite co. and is at present operated under lease by Doern & Sons of New Rochelle N. Y.

The opening is about 300 by 200 feet in area and 50 feet deep. Little water is encountered. The rock is a fine grained, light gray granite, intrusive in the pre-Cambrian gneiss, and is shown in section on pl. 52. The main set of joints strike nearly north and south, and dip about 70° to the east. A prominent hori-

zontal series of joints divides the rock into "lifts" from 1 to 8 feet thick.

Black powder is used in blasting, the holes being put in by Ingersoll steam drills, three of which are in use. Three derricks are in place at the quarry. By means of these the stone is lifted to the ground level and run on little trucks down a tramway to the dressing sheds. Little polished stone is sold, the greater part of the product being patent hammered. 10 cut work is the finest done; 6 cut is about the average finish. At present no paving blocks are made up. 35 to 40 men are employed through about 10 months of the year, in the quarry, dressing sheds and loading. The quarry and dressing sheds are shown on pl. 53.

From the dressing sheds the stone is transported by wagon to the river where a derrick is used in unloading it from the wagons and placing it on the scows.

Among the buildings recently erected of stone from this quarry are a church and a school building at Tarrytown, St Joseph's church (Tremont av. and Washington st. New York), the powder magazines at Iona Island and the guardhouse at West Point.

Round island, Rockland co. A granite quarry (31a) operated by Daniel E. Donovan on Round island has furnished large quantities of road metal.

The chemical composition of this granite is shown by analysis[1] to be:

	%
SiO_2	63.19
Al_2O_3	10.5
Fe_2O_3	10.97
FeO	1.51
CaO	6.12
MgO	1.44
K_2O	4.02
Na_2O	1.92

Pine Island, Orange co. Granite quarries have been operated on Mt Adam (33), Mt Eve (34) and Pochuck mountain (32).

[1] U. S. geol. sur. 20th an. rep't. Pt 6, continued, p. 421.

E. C. Eckel, photo.

King's quarry, near Garrisons N. Y.
(granite, intrusive in the pre-Cambrian)

E. C. Eckel, photo.

Dressing sheds, King's quarry, Garrisons N. Y.

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The granite quarried by the Pochuck granite co. was tested[1] by Prof. J. P. Carlin, with the following results.

Compression tests of granite

No.	Size of cube in inches	Area	First crack at	Ultimate strength	
				Total	per sq. inch
1	2.02 by 1.98 by 2	4 sq. in.	66 500 lb	94 000	23 500
2	2 by 2.1 by 2	4.2 sq. in.	74 000 lb	96 000	22 900

Harrison diorite

The Harrison diorite is a medium grained granite diorite, containing typically quartz, plagioclase (with subordinate orthoclase and microcline) and biotite. In Westchester county it covers a large part of the towns of Mamaroneck, Rye and Harrison, and the same area extends eastward into Fairfield county, Ct. as far as Stamford. In the New York portion of the area it is intrusive in the Hudson schist.

In that part of the Harrison diorite area which falls in Westchester county the diorite is generally highly foliated and often somewhat disintegrated on the outcrop. It is only quarried at one point in the area, which is described below. Several Connecticut quarries are also noted.

Larchmont, Westchester co. Campbell's quarry (35) is owned and operated by W. H. Campbell of Larchmont. All the product so far has been used on buildings erected by Mr Campbell. The quarry has been worked for about four years, and the total output is estimated at 4000 cubic yards. This is all used as dressed stone (bush hammered). The stone is of good quality. It is not much foliated, and has a rather pleasant bluish color. It is said to stand dressing well. In addition to the quartz and plagioclase, however, it contains much biotite and numerous garnets about $\frac{1}{8}$ inch in diameter. Sheared orthoclase is very infrequent. In a slide the feldspars are seen to be somewhat clouded but the biotite is very fresh.

[1] U. S. geol. sur. 20th an. rep't. Pt 6, continued, p. 421.

East Portchester, Fairfield co. Ct. A small quarry (36) in Harrison diorite is worked by Antonio D. Parlo & Son near the corner of Henry st. and Bridge st., Port Chester. This quarry is on the Connecticut side of the line but is included here for completeness. The total product is probably less than 500 cubic yards a year, including macadam, rough stone and a small amount of bush-hammered (patent hammered) stone. A granite dike about 10 feet wide cuts the diorite near the opening and material from it is occasionally used by the above firm.

Greenwich, Fairfield co. Ct. Large quarries (37) in the Harrison diorite are located just south of the New York, New Haven & Hartford railroad tracks, between Port Chester N. Y. and Greenwich Ct. The diorite is here much more massive than in the New York portion of the area and has long been valued as a building stone. The facilities for shipping are excellent, the quarries being almost at the water's edge. The diorite area extends to near Stamford, and small quarries (38) occur at several points within its boundaries.

Cortlandt series: gabbro and diorites

The dark colored, basic rocks of the Cortlandt series cover an area of about 20 square miles in the towns of Cortlandt and Yorktown, Westchester co. Much of the material is suitable for use as macadam, but unfortunately the best material is not near the Hudson river. Much stone has been quarried (39) near Quaker Bridge, Westchester co., for use in the new dam across the Croton river. This rock has been reported on by Prof. J. K. Kemp. An analysis[1] made for him by H. T. Vulté, follows:

SiO_2	54.72
Al_2O_3	17.79
Fe_2O_3	2.08
FeO	6.03
CaO	6.84
MgO	5.85
Na_2O	3.02
K_2O	3.01

The specific gravity of the above rock is stated[1] as being 2.928.

[1] Kemp. Handbook of rocks. Ed. 2. 1900. p. 49.

Plate 54 To face p. r167

E. O. Eckel, photo.

Poughquag quartzite, Peekskill Creek, showing slaty cleavage

Plate 55 To face p. r167

E. C. Eckel, photo.

Quarry in Poughquag quartzite, near Adams Corners, Putnam co. N. Y.

A mica diorite of the Cortlandt series was tested[1] for compressive strength, crushing at 20,250 lb a square inch.

Newark diabase

The "trap" of the Newark system has been long known as a valuable road metal. Large quarries (40) in this rock are located north of Nyack, Rockland co.; while a quarry (41) has been recently opened near Mt Ivy, Rockland co. Tests of material from several of these quarries will be found recorded on p. r14–r22 of the 20th report of the state geologist 1900.

SANDSTONES: INCLUDING SHALES

Poughquag quartzite

In Westchester county the Poughquag quartzite is a very hard and compact siliciously cemented sandstone, occurring at the contact between the Fordham gneiss and Stockbridge limestone. The formation has a thickness of at least 30 feet near Hastings but thins out on going south or east. The rock is prevailingly light colored and very evenly and thinly bedded, the slabs varying usually from ¼ inch to 2 inches in thickness. This, with the closeness of its jointing, usually prevents even moderate sized blocks from being obtained. The rock therefore, though highly durable, is of little economic importance. It has been used however as coping for a retaining wall on Warburton avenue near Hastings. At this point it was obtained in slabs about 4 feet by 3 feet by 3 inches and makes an ideal coping.

Near Adams Corners in Putnam county is a small quarry in this formation (43). One of the openings, now almost hidden by vegetation, is shown on pl. 55. The product was used for furnace lining.

Hudson shales and sandstones

Prof. William B. Dwight states that in Dutchess county the sandstone of the Hudson formation is everywhere fine grained and very irregularly bedded; and that it is of only local use as building stone. Quarries in the thicker beds have been worked near Highland, Ulster co.; and the shales of the formation have been quarried to some extent in Orange county for use as road metal.

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[1]Newberry. School of mines quarterly, July 1887.

Green Pond conglomerate

Central Valley, Orange co. The Green Pond conglomerate has been used to a small extent for foundation and wall stone. The small bridge, one arch of which is shown on pl. 56, is located near Central Valley, Orange co. and was built under the direction of Mr Richard Ficken from blocks of Green Pond conglomerate. Used in the manner shown, it is a decidedly attractive material and much preferable to the rough dressed limestones so often used for similar bridges and walls.

Pine Hill quartzite

The white and red quartzites of the Pine Hill formation are well exposed along the crest and at the southern end of Pine hill. They have been little used, as their hardness makes dressing difficult. It is probable that they could be profitably exploited, and that stone of this quality and color would find a ready market in New York city.

Longwood red shales

Highland Mills, Orange co. Several quarries (46) in this formation along the west side of Pine hill, near its southern end, are worked rather extensively. The red shales are used on most of the roads in the neighborhood, and, for light traffic, are an admirable road metal. Under heavy traffic, however, specially in wet weather, they grind up into a fine stiff clay.

Bellvale flags

Monroe, Orange co. Two quarries in the Bellvale flags are near Monroe. The first, the Davison quarry (45), is located near the Seven Springs Mountain house; the second, that of O. H. Cooley (44), is nearer Monroe. The beds worked at both quarries are thin and irregularly bedded flagstones, gray in color, and with much waste material. The quarries have, however, furnished a considerable amount of material for local use as steps, curbing, flagging, etc., as no other material suitable for these purposes occurs in the vicinity.

Plate 56 To face p. r168

E. C. Eckel, photo.

Arch of bridge near Central Valley, Orange co. N. Y.
Built of Green Pond conglomerate

Newark sandstone

Nyack and Haverstraw, Rockland co. The reddish brown sandstones of the Newark system were formerly quarried (47) extensively in Rockland county. At present the product is still of some importance, but is used locally only.

LIMESTONES: INCLUDING MARBLES

Cambro-Silurian (?) limestones of the Highlands

Several of the areas of white limestone in the Highlands of Putnam and Orange counties have been worked for lime; a few have furnished stone for local building purposes. The only quarry of sufficient interest to warrant notice here is described below.

Cold Spring, Putnam co. Heustis's quarry (49), which has not been worked for many years, is located about 4 miles northeast of Cold Spring, Putnam co. The product, a serpentine marble, was obtained from an outcrop of limestone on the western bank of a small brook. In the brook thin bedded quartzite appears. As both limestone and quartzite can be traced, though with frequent breaks, to the northward, till the valley opens out into the great Paleozoic plain of Dutchess county, it seems probable that they are merely very highly crystalline representatives of the Stockbridge limestone and Poughquag quartzite respectively. At Heustis quarry the marble is heavily charged with silicates, whose presence may be attributed to the intrusion of a dike of red granite which outcrops near the quarry. The serpentinous portions of the marble are not sufficiently large or firm to warrant exploitation and the quarry is merely of historic interest.

Stockbridge and Barnegat limestones

The Stockbridge limestone was formerly highly esteemed as a structural stone, and many quarries worked it for such use. Of late years, however, its popularity has declined, and only one limestone quarry is now producing building stone in the area under discussion.

The rock is, however, of great value for other purposes. In its less crystalline condition (as shown at Tomkins Cove and Stoneco) it is very important as a source of road metal. A number of quarries are still working, but only one produces building stone. The others crush the material, either selling it as marble dust, for use in the manufacture of carbonated waters and also in asphalt paving mixtures; or burning it into lime, to be used for chemical or structural purposes. Wherever a magnesia lime is serviceable, the product of these quarries can be utilized. In early times lime was burnt at several points between Yonkers and Lowerre, as well as north of Spuyten Duyvil, several old kilns still being visible near the Hudson river.

Tuckahoe, Westchester co. *Norcross Bros. quarry.* This, the northernmost (53) of the principal quarries at Tuckahoe, was opened in 1854. It was worked by A. Maxwell, then by A. T. Stewart, and is noted in Smock's report as the Stewart quarry. It is now operated by Norcross Bros. under the superintendency of Mr J. M. Masterton. The quarry is opened for a distance of about 600 feet along the strike and is 150 feet wide and 70 deep. No lime is burned and all the product is marketed as dressed stone. During the entire time of its working, the maximum annual production was about 60,000 or 70,000 cubic feet. During late years the principal buildings supplied were the Home Life (rebuilding), the Clark mansion (80th st. and Riverside drive), and the New York Life—all in New York city.

Three boilers are in service—one 100 horse power in the mill, and an 80 horse power and 50 horse power in the quarry. The water is obtained from a spring in the quarry and requires no treatment. An air compressor is used, which runs the drills and the pneumatic tools in the mill. The compressor, drills, quarry-bar and gadders are Ingersoll-Sergeant; the six channelers are Sullivan. In the mill are seven gangs of saws, four planers, three turning lathes and three rubbing beds.

The dip is steep, 70° or so to the west. In the more openly bedded parts of the quarry wedges are used to separate the

slabs. In closely bedded parts channelers make cuts 12 feet deep and 2 inches wide, on the dip. These cuts are put in about 42 inches apart. Gadders or drills mounted on quarry bars are then used to put in rows of horizontal holes at right angles to the strike. Wedges in these holes release the stone in slabs of the desired size. Powerful derricks then lift the blocks to the level of the mill. After dressing it is sent down a side track to the Harlem railroad above Tuckahoe. No explosives are used.

Tuckahoe marble company's quarry. This (52) is next south of the above, is idle now, and has not been worked for five years or more.

New York quarry co. This quarry (51) is the southernmost of the Tuckahoe quarries and was formerly known as the Masterton quarry. One of its two openings is idle, the other and larger is worked under lease by O'Connell & Hillery, the stone being crushed for "marble dust" or burned into lime. The rock is blasted, hammer-broken into pieces of convenient size and carried by cableway to the kilns.

Analyses of the stone from the O'Connell and Hillery quarry follow. Several of these have been erroneously quoted in different state and federal publications, the analysts' names being given incorrectly and the analyses being referred to the Norcross quarry.

	1	2	3	4
SiO_2	.....	2.4	.....	.24
Al_2O_3	.....	2.15	.....	.19
Fe_2O_3	.21		.....	.21
$CaCO_3$	.....	88.36	70.1	.....
CaO	30.68	.....	.....	30.16
$MgCO_3$	.....	12.09	25.4	.....
MgO	20.71	.....	.....	21.25
CO_2	46.66	.....	.....	47.3
Insoluble	1.33	.....	.....	.....

1 W. F. Hillebrand, analyst, 1887.
2 H. L. Bowker, analyst, 1894.
3 17th an. rep't U. S. geol. sur. pt 3, p. 796.
4 P. de P. Ricketts, analyst, 1887.

White Plains, Westchester co. A quarry (57) has been opened in the Stockbridge limestone just west of the tracks of the New York and Harlem railroad and about 1 mile north of White Plains. It is operated by James O'Connell. All the rock quarried is burned into lime or used as crushed limestone. Views at this quarry are shown on pl. 57 and 58. An analysis of the limestone, made by Huntington in 1899 follows:

SiO_2	2.08
Al_2O_3 and Fe_2O_3	.56
$CaCO_3$	58.72
$MgCO_3$	37.79
(Available CO_2	45.57)

Hastings, Westchester co. At Hastings the old quarry (55) is unworked, and is merely of historic interest. West of the old Croton aqueduct a quarry was opened in a thin bedded and brownish limestone, very micaceous. The product was intended for the asphalt blocks of the Hastings paving co. but proved unsatisfactory.

Pleasantville, Westchester co. Several large quarries (58) in the Stockbridge limestone are located south of Pleasantville, near Unionville station. The product has been largely used, both for structural purposes and for burning into lime. The marble from these quarries is coarser grained than that from Tuckahoe, and lost public favor earlier. The lime quarries and kilns, however, have been worked till lately. Analyses of Pleasantville limestone follow:

	1	2	3
SiO_2	2.31	.1	.29
Al_2O_3	.49	.07	.....
Fe_2O_3	.25	.16	.....
$CaCO_3$	59.84	54.62	54.8
$MgCO_3$	36.8	45.04	43.11

1 H. Ries, analyst, N. Y. state mus. 51st an. rep't, p. 466.
2 "Columbia college," U. S. geol. sur. 16th rep't, pt 3, p. 468.
3 Wilber, analyst, N. Y. state mus. Bul. 10.

Ossining, Westchester co. Marble was formerly quarried on land belonging to the state near Ossining. The following anal-

Plate 57 To face p. r172

E. C. Eckel, photo.

O'Connell's quarry, near White Plains N. Y.
View of elevator, kilns etc.
(Stockbridge limestone)

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Plate 58

To face p. r172

E. C. Eckel, photo.

O'Connell's quarry, near White Plains N. Y.
View of main opening
(Stockbridge limestone)

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H. Ries, photo. Marble quarry, Ossining, Westchester co. (Stockbridge limestone)

ysis of " marble from Sing Sing," is given by L. C. Beck[1] and apparently is of material from this quarry.

$CaCO_3$	53.24
$MgCO_3$	45.89
SiO_2, Al_2O_3, Fe_2O_3	.87

Two large quarries (60, 61) in the Stockbridge limestone have long been worked near Ossining, part of the product being shipped for use as flux and part being burned into lime. These quarries are worked by Henry Marks and the Sing Sing lime co., respectively. Analyses[2] of the rock follow.

SiO_2	.98	.87
Al_2O_3	.84	.57
Fe_2O_3	.3	.25
CaO	31.4	31.4
MgO	16.96	19.95

Oscawana, Westchester co. Tat's quarry (65) is located about 2 miles northeast of Oscawana station. Very little stone has been taken out and the opening is not at present worked. The product is a very white and very fine grained marble. The quarry could not be closely examined when visited, as the opening was filled with water, but if blocks of large size can be obtained the product should be readily marketable, as the quality is excellent, so far as color and grain are concerned.

Bedford, Westchester co. Several small quarries (62) east and northeast of Bedford in the Stockbridge limestone, were formerly worked, the product being burned into lime for local use.

Armonk, Westchester co. Quarries just north of the Connecticut line were formerly worked rather extensively, all the product being burned into lime.

Golden's Bridge, Westchester co. Todd's quarry (64) is situated about 3 miles east of Golden's bridge. It is a small quarry, in a rather highly contorted limestone, and has not been worked for the past 10 years. The stone does not appear to be fit for cutting, though a mill is located near the opening.

Marble has been quarried at Patterson and Towners (66), Putnam co.; but the product was not large and the quarries have been idle for some years.

[1] N. Y. geol. sur. 3d rep't. 1839. p. 19.

[2] Ries. N. Y. state geol. 17th an. rep't. 1899. p. 463.

South Dover, Dutchess co. The South Dover marble co. operates a large quarry (67) about 2 miles northeast of Wing station. The product, all of which is used for structural purposes, is carried to the railroad at Wing on an electric trolley road built by the company for that purpose. An analysis of the marble made by Ricketts and Banks follows:

SiO_2	.7
Fe_2O_3	.25
Al_2O_3	.37
CaO	30.63
MgO	20.25
Na_2O	.12
K_2O	.46

Dover Plains, Dutchess co. This quarry was not visited by the writer, and the following description is therefore quoted from Ries.[1]

At Dover Plains, G. & J. H. Ketcham have operated a quarry along the highroad ½ mile southeast of the town. The rock is a soft, fine grained dolomite of gray or white color. The opening is about 200 feet long, 20 to 30 feet wide and 10 feet deep. No analysis was made of the stone but several samples were examined to determine their insoluble matter, which ran from 2 to 3 per cent.

Small marble quarries have been operated at several other points in eastern Dutchess county, notably near Pawling and Dover.

Stoneco, Dutchess co. Large quarries (68) in the blue silicious limstone have been opened on Clinton point, on the east side of the Hudson river, north of New Hamburg. These quarries are operated by the Hudson River stone supply co. All the product is used as road metal, to which use it is particularly well adapted. Samples from these quarries have been tested for binding power, wear, etc., and the results of these tests will be found reported on p. r14–r22 of the 20th report of the state geologist.

Ries gives the following analysis of the limestone from Clinton point.

SiO_2	10.17
Al_2O_3	2.33
Fe_2O_3	.47

[1] Ries. N. Y. state geol. 17th an. rep't. 1899.